Disease as a Failure of Homeostasis

Disease is any condition that prevents the body from working as it should. As a result, the body may fail to maintain homeostasis. Diseases in humans may result from foreign invader organisms, called **pathogens,** or from abnormal cells in the body that lead to cancer. Disease may also result from toxic substances, poor nutrition, organ malfunction, an inherited disorder, or risky personal behavior. All can lead to a disruption of the body's ability to function normally—that is, to maintain homeostasis.

Sometimes the onset of a disease becomes apparent right away, as in the case of some birth defects or poisoning. Sometimes, however, the disease may not show up for many years, as is the case with lung cancer caused by exposure to tobacco smoke. Some examples of these kinds of diseases are noted in Table 2-5.

Table 2-5. Causes of Disease

Cause of Disease	Examples
Inherited disorders	Down syndrome, cystic fibrosis, sickle cell disease
Exposure to toxins	Lead poisoning, radiation poisoning
Poor nutrition	Scurvy (vitamin C deficiency), goiter (iodine deficiency)
Organ malfunction	Heart attack, diabetes
High-risk behaviors	Lung cancer, drug addiction, skin cancer

Pathogens There are many potentially dangerous disease-causing organisms in the air, water, and food we take in every day. A variety of pathogens—viruses, bacteria, fungi, and other parasites—can interfere with our normal functioning and make us seriously ill. Plants and other animals can also be infected by these and similar organisms. Some examples of pathogens and the diseases they cause are shown in Table 2-6.

Cancer Certain genetic mutations in a cell can result in uncontrolled cell division called cancer. Exposing cells to certain chemicals and radiation increases mutations and thus increases the chance of cancer. In this disease, genes that control and coordinate a cell's normal cycle of growth and division are altered by mutation. As a result, the cell begins to divide abnormally and uncontrollably. The result is a mass of abnormal cells referred to as a tumor.

Table 2-6. Pathogens and Disease

Pathogen	Description of Pathogen	Examples of Disease
Virus	**Viruses** are particles composed of nucleic acid and protein. They reproduce when they invade living cells.	Examples include the common cold, influenza, AIDS, and chicken pox. Immunizations have been developed to combat many viral diseases.
Bacterium	**Bacteria** are one-celled organisms.	Bacterial illnesses include strep throat, syphilis, and food poisoning. **Antibiotics**, drugs like penicillin that we get from microorganisms, are used to treat many bacterial diseases.
Fungus	**Fungi** are organisms made of either one or many cells. They include yeasts and molds. They eat by absorbing organic substances.	Examples include athlete's foot and ringworm. Fungicides and antibiotics are used to fight fungal diseases.
Parasites	Some animals and one-celled organisms are **parasites** that survive by living and feeding on other organisms.	Parasites include leeches and tapeworms. Malaria is a disease caused by a one-celled organism. It is transmitted to humans by mosquitoes. Heartworm is a parasitic worm that lives in dogs and cats. Medicines are available to treat some parasitic diseases. Avoiding exposure to the parasite is also effective.

Once they are identified, often by abnormal proteins on their surfaces, cancer cells may be attacked by the immune system and destroyed. If the immune system is unable to destroy the cancer cells, the disease may become life-threatening.

The Immune System

Humans have many ways of protecting themselves from danger and disease. For example:

- Our eyes, ears, and sense of smell help us detect danger.
- We release hormones that stimulate emergency responses to danger.
- Our muscles allow us to fight off some threats and to flee from others.
- Our skin—when unbroken—keeps out many foreign organisms that could be harmful.
- Our tears, saliva, and other body secretions trap and/or destroy invaders that come into contact with them.
- Our nervous system provides rapid coordination of many of our responses to danger.

Once invaded, however, the body needs an effective way to combat invaders or body cells that malfunction. The **immune system** is the body's primary defense against disease-causing pathogens.

Pathogens, foreign substances, or cancer cells that threaten our homeostasis can usually be identified by molecules on their outer surfaces or membranes. These molecules, called **antigens,** trigger a response from the immune system. Toxins, the poisonous wastes of certain pathogens, can also act as antigens.

All cells have potential antigens on their surfaces. However, the immune system can usually tell the difference between the molecules of "self" cells, which belong to the body, and "non-self" (foreign) cells, which come from outside the body. When cells of our immune system recognize foreign antigens, specialized white blood cells and antibodies attack them and the cells that display them.

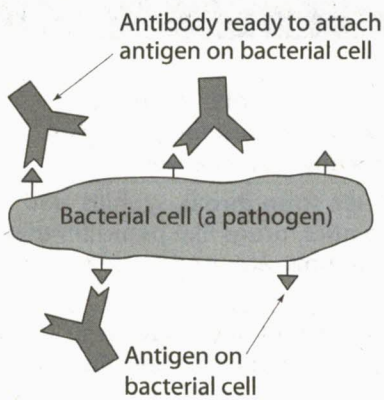

Figure 2-13. Certain white blood cells produce Y-shaped antibodies: The antibodies match the shape of certain antigens on pathogens or abnormal proteins on cancer cells. Note that the antibodies and antigens are not drawn to scale. They would be MUCH smaller than the pathogen cell.

White Blood Cells and Antibodies Some white blood cells are specialized to surround and engulf invading pathogens that are recognized as a threat. Others produce **antibodies**—proteins that either attack the invaders or mark them for killing. The marked invaders may then be destroyed by other white blood cells. In Figure 2-13, notice the Y-shaped antibodies that match the shape of antigens.

Most of the antibodies and white blood cells that attack an invader break down soon after they have defended the body. However, some specialized white blood cells will remain. These cells are capable of quickly dividing and producing more antibodies of the same kind to fight off later invasions of the same **microbes** (microscopic organisms). Antibodies are effective even against microbes that appear years later.

Vaccinations Scientists have discovered that weakened microbes (pathogens) or even parts of microbes can stimulate the immune system to react. The antigens found on the live pathogens are

usually present on the weakened or killed ones, too. As shown in Figure 2-14, **vaccines** are made using these weakened, killed, or parts of microbes (pathogens). When vaccines are injected into the body, the immune system responds just as if it had been invaded by a live pathogen. It produces antibodies. These antibodies can attack and destroy any of that pathogen that is still present in the body.

After a vaccination, the immune system "remembers" specific pathogens by leaving behind white blood cells that protect the body for years. The vaccinated body reacts as if it has already defeated the specific pathogen and responds faster in the future than it did when attacked the first time. The second response is so rapid that in most cases the disease will not even have time to develop before the immune system wipes it out.

Damage to the Immune System A person's immune system may weaken with age or other factors. Stress and fatigue, for example, can lower our resistance and make us more vulnerable to disease. Some viral diseases, such as **AIDS,** result from an attack on the immune system. Damage from the disease may leave the person with AIDS unable to deal with infections and cancerous cells. Their weakened immune system is one reason people with AIDS often die of infections that a healthy immune system would easily destroy.

Problems Associated with the Immune Response Although our immune system is essential for our survival, it creates problems for some people. These people have an **allergy**—a rapid immune system reaction to environmental substances that are normally harmless. Examples of such substances include certain foods, pollen, and chemicals from insect bites.

In people with allergies, the immune system reacts by releasing histamines. This leads to anything from a runny nose and sneezing to a rash and swelling. It is the swelling that makes some allergies dangerous: Occasionally, the throat swells, interfering with the victim's ability to breathe. People with allergies often use antihistamines to reduce the effects of the histamines and the symptoms they cause.

Sometimes the immune system fails to recognize the "self" molecules and attacks the body's own cells. For example, in some cases, the immune system attacks and destroys the pancreas cells that produce insulin. The result is one type of diabetes.

Since transplanted organs come from another person, they have foreign antigens on their cells. As a result, the immune system recognizes transplants as "invaders" and attacks them. To avoid "rejection" of their new organ, transplant patients receive injections of special drugs to reduce the effectiveness of their immune system. Of course, because the immune system's ability to protect the transplant patient from normal pathogens is reduced, the patient may become ill from a pathogen that normally would be no threat.

MemoryJogger

Remember germs? At one time *germ* was the word of choice for people who were talking about the tiny living things that cause disease. *Germ*, however, had two meanings in science, so the term *microbe* became the more accurate word choice. You still need to know that a microbe is any microscopic organism, but scientists now usually use the term *pathogen*. The reason is that the meaning of pathogen also includes viruses, those tiny "almost-organisms" that don't quite fit the description of a living thing.

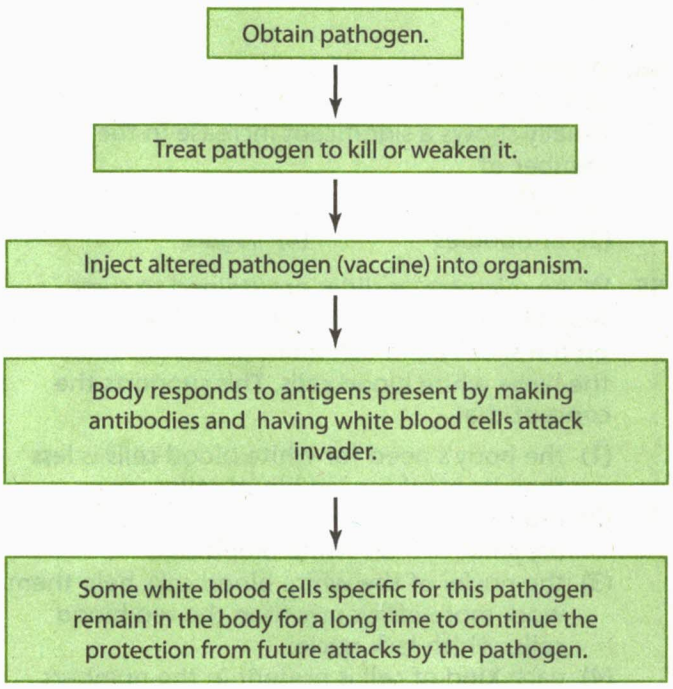

Figure 2-14. Preparation and use of a vaccine

Research and Progress Against Disease Biological research of diseases and their causes has generated a vast amount of knowledge that is used to find ways of diagnosing, preventing, controlling, or curing diseases of plants and animals. Some examples of how medical knowledge has developed are shown in Table 2-7.

Table 2-7. Biological Research of Diseases

Category of Research	Methods Developed
Diagnosing disease	• Culturing (growing) bacteria from the infected person to determine what specific pathogen is responsible for the illness • Using X-rays, CAT scans, ultrasound, blood pressure monitoring devices, and other methods to determine the cause or extent of the illness • Detecting genetic abnormalities that may be present in cells
Preventing and controlling disease	• Promoting improved sanitation measures, including frequent hand washing, safe garbage disposal, and sewage treatment • Sterilizing surgical instruments and treating wounds with antiseptics and other chemicals • Controlling populations of rats, flies, mosquitoes, and other disease-carrying organisms with pesticides or sanitation measures • Treating water, milk, and other foods to reduce the presence of pathogens • Vaccinating to promote the body's immune response to pathogens • Identifying the dangers of risky behaviors such as tobacco use
Treating and curing disease	• Developing antibiotics and other drugs to kill pathogens • Developing medical procedures, including surgical operations and laser techniques, to remove damaged or diseased tissue from the body

Review Questions

54. When a person is suffering from an infection, such as strep throat or chicken pox, his blood usually shows a significant increase in the number of

(1) enzymes (3) hormones
(2) antibodies (4) sugars

55. When microscope slides are stained to show blood cells, the small red blood cells that appear on the slides are much more numerous than the large white blood cells. This supports the concept that

(1) the body's need for white blood cells is less than its need for red blood cells
(2) red cells are more numerous because they are smaller than white blood cells
(3) the nuclei of the white blood cells help them work more efficiently than the red blood cells, which lack nuclei
(4) each kind of cell is present in the numbers best suited to meet the needs of the body

56. Which response usually occurs after an individual receives a vaccination for the influenza virus?

(1) Hormones in the blood stop reproduction of the virus.
(2) Pathogens from the vaccine deactivate the virus.
(3) Enzymes released from antigens digest the virus.
(4) Antibodies against the virus are found in the blood.

57. A patient has just received an organ transplant. Which treatment would be most effective in preventing the patient's body from rejecting the organ?

(1) Treat the patient with medications that decrease the immune system's response.
(2) Treat the patient with antibiotics to fight off a possible viral infection.
(3) Restrict the patient's salt intake.
(4) Give the patient blood transfusions.

58. The body makes chemicals that can help to destroy harmful viruses and bacteria. These chemicals are called

(1) antibodies
(2) vaccines
(3) hormones
(4) antibiotics

59. A vaccine can protect you against a disease because it

(1) destroys toxic substances from bacteria before they can make you sick
(2) stimulates your immune system against the pathogen
(3) kills any pathogenic bacteria in your body
(4) changes pathogenic bacteria into harmless bacteria

60. The body is protected against harmful flu viruses by

(1) red blood cells and hormones
(2) white blood cells and antibodies
(3) white blood cells and enzymes
(4) red blood cells and antibodies

61. A scientist wishes to determine how effective a vaccine is in protecting rats against a contagious disease. Which experimental procedure should the scientist use to determine the vaccine's effectiveness?

(1) Expose 100 rats to the disease and then vaccinate them all.
(2) Give vaccinations to 50 of the 100 rats and then expose all 100 to the disease.
(3) Give vaccinations to 100 of the rats and expose them all to the disease.
(4) Vaccinate 50 of the 100 rats and then expose only the 50 vaccinated rats to the disease.

62. Parasitic strains of *E. coli* may produce poisonous chemicals that attack living tissue and cause disease in humans. These chemicals are called

(1) antibodies
(2) toxins
(3) viruses
(4) antibiotics

63. Uncontrolled cell division is known as

(1) meiosis
(2) cancer
(3) antibody production
(4) sexual reproduction

64. The resistance of the body to a pathogen is called

(1) immunity
(2) antigen
(3) cancer
(4) infection

65. Diseases can be caused by inherited disorders, exposure to toxic substances, organ malfunction and certain personal behaviors.

Choose *two* of the above causes and *for each one* give a specific example of an associated disease. [1]

66. Our immune system normally helps us resist infection and disease. Sometimes, however, it may actually work against us by attacking certain tissues or organs in the body.

State one example of the immune system attacking the body and explain how we try to counteract the problem. [1]

67. Vaccinations play a major role in medicine today. Explain the role of vaccines in the prevention of disease. Your answer must include at least:

- a description of the contents of a vaccine [1]
- a description of how a vaccine protects the body from disease [1]
- one specific reason certain vaccinations are required for students to attend public schools. [1]

68. Biological research has generated much knowledge about diagnosing and preventing disease.

Give one specific example of how research has helped us *diagnose* a disease and one specific example of how research has helped us *prevent* a disease. [1]

69. Various kinds of pathogens cause illness or interfere with body functioning. For each pathogen type listed below, identify one specific organism or disease associated with that type of pathogen.

Pathogen Types:

(a) virus
(b) bacteria
(c) fungus
(d) other parasites